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CENTRAL RICE RESEARCH INSTITUTE, CUTTACK

**COMBINED ANNUAL REPORT
FOR 1949-50 AND 1950-51**



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CENTRAL RICE RESEARCH INSTITUTE

Cuttack, Orissa

Combined Report for 1949-50 and 1950-51

WEATHER AND CROP CONDITIONS.

The season during both the years was not very favourable for rice. In 1949-50 the total rainfall of 49.78 inches was short by 7 inches, while in 1950-51 there was an excess precipitation of 9 inches when compared to the normal. The distribution of the rains was also not optimum as the quantity received in July during transplanting was not adequate. The broadcast crop, therefore, suffered due to the long dry spell and crop in the unirrigated single crop high level fields was smothered by weeds. In 1950-51, on the other hand, there was a cyclone with high precipitation in August-September with the result that some of the transplanted fields were submerged. There was a heavy gale also in November which resulted in the bad lodging of the crop in the ears. The yields of both years were, therefore, affected and were low. Regarding diseases there was a severe attack of 'blast' in late sown main crop seed-bed. In the planted crop during both years, the 'blast' disease was not severe except in the intensively manured area. Regarding insect pests there was no severe attack except in second crop where there was some incidence of 'stem borer'.

AGRONOMY

A-VARIETAL TRIALS.

Ten varietal trials were conducted during the two seasons under report with the improved types received from the States as well as from outside India and with the promising cultures brought forward from preliminary yield trials from the genetic stock collection. In these trials varieties of more or less the same duration were tried together along with the local improved types of similar duration with a view to select higher yielding varieties with desirable agronomic characters such as non-lodging habit, etc.

(i) *Early duration trials.*—Experiments were conducted with early maturing Chinese, Japanese and Russian varieties using the local variety "*Benibhog*" as the standard. The crop was transplanted with 9" x 9" spacing in the first year but the spacing was reduced to 4" x 4" in the second year as wider spacing was not found optimum for early types. The highest yield was obtained with the local variety, followed by Chinese types while both Russian and Japanese types gave very poor yields. It was concluded that the Japanese or Russian varieties are not suitable for direct introduction. During the second year's trial, two Indian types, Adt.4 and Adt.20, which were included in these trials gave higher yield than the local standard employed, namely, "*Benibhog*" by 32 and 52 per cent. respectively, the yield obtained in "*Benibhog*" being 1117 lb. per acre. These will be further tested.

The above trials were conducted both under manured and unmanured conditions. The manuring was done by applying ammonium sulphate at the rate of 60 lb. N per acre. The average response to manuring was about 480 lb. per acre. Neither the Japanese nor Russian varieties gave higher response to manuring as compared with other varieties.

(ii) In another trial conducted with 36 varieties of 85—105 days duration with the local variety 'Benibhog' as standard, five of them were superior to 'Benibhog' giving 16 to 40 per cent. higher yield. The best among these were Adt.15, Ptb.10 and Co.21. The trial will be repeated again with these varieties next season.

(iii) In the trials with varieties of 110—120 days duration the varieties Adt.9 and Mtu.9 were superior in yield to the local standard, T.608, CP.15 which was tested only for one season (1950-51) gave the highest yield.

(iv) The trials with varieties of 125—140 days duration were conducted with a local high yielding variety, T.1145, as the standard. Varieties, Slo. 6 and Slo. 9, were found as good as T.1145, in both the years, while Bam. 1 was found to give 22.7 per cent. more yield than T.1145 in 1950-51 and this variety would be tested further.

(v) Nine varieties of 160—170 days duration were tried against T.90. Three of the varieties, namely, Bam. 9, T.165 and Bam. 6, have yielded significantly higher than T.90. The maximum yield was obtained with Bam.9, the increase over T.90 being about 20 per cent.

(vi) In another trial conducted with varieties of over 170 days duration, the varieties Ptb.4, Co.16 and Akp.11 gave significantly higher yield than the local standard, T.1242, the increase being of the order of 22—26 per cent. Though under conditions similar to those obtained in Central Rice Research Institute, no variety of such long duration is usually grown, there are low lying areas where the growing of long duration varieties will be desirable and the varieties with a good performance will suit such conditions better than the local variety, T.1242.

The above varietal trials were conducted both under manured and unmanured conditions. The manuring was done with ammonium sulphate at the rate of 20 lb. N per acre. All varieties responded to manuring. However, in 1949-50, the variety, Ptb.13, gave a high response of 867 lb. per acre compared with the average response of 294 lb. per acre for all varieties.

B-CULTURAL TRIALS.

(i) *Summer ploughing vs. summer fallowing.*—In heavy soils, summer ploughing did not confer any benefit in terms of higher production.

(ii) *Double transplanting.*—The advantage of double transplanting of rice, represented to be a common practice in Korea, was tried in 1948-49 with the variety FR.43B, of 160 days duration. During the year 1949-50 the experiment was repeated with three varieties, FR.43B, T.90 and T.1242, all of about 160 days duration and was

again repeated in 1950-51 with the varieties T.90 and T.1242. There were four treatments in all, (i) planting 30 days old seedlings in the proper season in field, (ii) transplanting 30 days old seedlings as in above but closely in seed-bed and re-transplanting the seedlings in the field after another 30 days, (iii) transplanting the seedlings from the seed-bed after 60 days, and (iv) sowing the seed-bed 30 days late to get 30 days old seedlings at the time of double transplanting as in (ii) above. The first treatment gave the highest yields with all the three varieties followed closely by the second, but the third and fourth treatments gave very poor yields. Double transplanting appears to be an expediency to counteract the deleterious effects of planting late in the season or planting too old seedlings.

C-MANURIAL TRIALS.

(i) *Residual effect of organic and inorganic nitrogenous manures.*—Two experiments, one under broadcast and the other under transplanted conditions, were conducted in 1948-49 for comparing groundnut cake and ammonium sulphate as manures for rice. Both ammonium sulphate and groundnut cake had given significant increase in yield over no manure in these plots, but no significant differences were observed between the yields of the different plots in crop raised next season indicating that neither of the two forms of manure had any residual effect in rice soils.

(ii) *Comparison of ammonium sulphate and ammonium nitrate applied in different periods of plant growth.*—This experiment was designed to determine the suitable form of nitrogenous fertilizer and the optimum time of its application for varieties of different durations. The experiment commenced in 1948-49 and was continued during the two years under report. The fertilizers ammonium sulphate, ammonium nitrate and mixture of the two, each at two levels, 20 and 40 lb. of N per acre, were applied to two varieties, viz., one of medium duration and the other of late duration. The time of application of the fertilizer consisted of (1) application at planting, (2) application one month after planting, (3) application of half at planting and half one month after planting. On the basis of three years' results it is concluded that (i) ammonium sulphate is superior to ammonium nitrate, (ii) the mixture of the two fertilizers was more or less as efficient as ammonium sulphate, (iii) the application of half the dose at planting and the other half one month after transplanting or applying the entire quantity as a single dose one month after planting were more efficient than applying the entire amount at planting, and (iv) increasing the level of nitrogen from 20 lb. N per acre to 40 lb. N per acre increased the yields to a certain extent, but the additional increase was small and not consistent.

There was no differential response with varieties for fertilizer forms or for method of application of the fertilizer.

(iii) *Efficiency of different nitrogenous fertilizers for rice.*—The object of this experiment was to compare the relative efficiency of some of the important forms of nitrogenous fertilizers at different levels of application and on varieties of different durations. The fertilizers included were, ammonium sulphate, ammonium phosphate, urea and ammonium nitrate. The findings from these experiments were (1) when compared on equal nitrogen basis ammonium sulphate gave

the best response although urea was as good as ammonium sulphate in one year, (2) ammonium nitrate gave about 60 to 70 per cent. of response obtained with ammonium sulphate.

(iv) *Comparing the methods of application of ammonium sulphate in wet and dry soil conditions.*—The customary practice of applying ammonium sulphate to the rice crop is to apply the fertilizer under wet soil conditions at transplanting, while the practice adopted in Japan is to apply the fertilizer in dry soil condition. 2"-3" deep before water is let in the field for puddling. With the object of comparing the efficiency of these two methods, two experiments, one in average and the other in low lying land, were conducted during the two years. Nitrogen was applied at the rate of 20 lb. N per acre in both years. The average yields obtained are given below :

Yield in lb. per acre
(average for 1949-50 and 1950-51)

Type of land	No manure (control)	'Dry' application	'Wet' application	Mean
Medium land	1605 (100)	1893 (117·9)	1796 (111·9)	1765
Low land	1728 (100)	2114 (122·3)	1967 (113·8)	1936
Mean	1667 (100)	2003 (120·1)	1882 (112·8)	1851

The figures in brackets indicate percentage on control.

The above figures clearly indicate the superiority of the 'dry' method of application over the usual 'wet' application although the latter method of application has also given a significant increase in yield over no manure.

(v) *Combination of organic (green manure) and inorganic (ammonium sulphate) fertilizers.*—This experiment was designed to compare the relative efficiency of green manuring, ammonium sulphate and combination of the two. The levels of nitrogen tried were 0, 10, 20, 30, lb. N per acre. For green manuring *Dhaincha* (*Sesbania aculeata*) was grown elsewhere and the appropriate quantity for each treatment was brought and trampled in. Ammonium sulphate was applied as a top-dressing after the planting. The results obtained are given in the following table:

Yield, lb. per acre, of different levels of N in the form of green manure, ammonium sulphate and combination of two

	Levels of N.	Basal dressing of green leaf				Mean	Significance
		0	10	20	30		
Top dressing of ammonium sulphate.	0	2181	2376	2762	2694	2503	C. D. for marginal means =14·3.
	10	2220	2604	2473	2636	2483	
	20	2429	2745	2655	2733	2641	
	30	2480	2675	2871	2791	2682	C. D. for marginal means =284·5.
	Mean	2327	2600	2668	2713		

It may be seen that green manuring by itself gave a better response than ammonium sulphate on equal nitrogen basis. The response curve for ammonium sulphate showed no departure from linearity while that for green manure showed a quadratic trend. The corresponding regression equations were:

Ammonium sulphate $Y = 2161.2 + 11.06X$

Green manure $Y = 2148.3 + 39.6X - 0.66X^2$

where Y was the expected yield in lb. per acre and X the dose of N in lb. per acre. Thus the yield response per lb. of N was 11.06 lb. for ammonium sulphate and 25.9 lb. for green manure at the dose of 20 lb. N per acre. While the combination of ammonium sulphate and green manuring was superior to ammonium sulphate alone, it was not superior to green manuring on the same nitrogen basis.

(vi) *Continuous manurial trials.*—These experiments were being conducted to study the cumulative effect of continuous application of the fertilizer, ammonium sulphate on soil condition and productivity. Owing to the absence of laboratory facilities no complementary soil study has been taken up yet. But whether addition of compost or lime to the ammonium sulphate treated soils had any ameliorative effect was tested in the experiments.

- (a) *Ammonium sulphate with and without lime.*—The experiment was started in 1948-49 and was continued during the two years under report. Ammonium sulphate was applied every year to the same plots, the rate of application being 0, 20 and 40 lb. N per acre. Lime was applied every alternate year, commencing from 1948-49, the rate of application being 0, 4 and 8 cwt. per acre. Nitrogen application alone or in combination with lime gave responses which increased almost proportionately with increase in nitrogen level up to the highest dose of 40 lb. N per acre. The rate of response was about 18.7 ± 2.4 lb. and 15.4 ± 1.2 lb. per acre for every lb. of nitrogen applied in 1949-50 and 1950-51 respectively. In both 1949-50 and 1950-51, when lime was applied, there was no response to lime nor there was interaction of nitrogen level with lime. However, the period of experimentation is too short for detecting any cumulative effect of the treatments and no definite conclusion can be drawn on this aspect till data for a few more years are available.
- (b) *Ammonium sulphate with and without compost.*—This experiment was started in 1949-50. The treatments consisted of five levels of nitrogen, viz., 0, 20, 40, 60, and 80 lb. N per acre in the form of ammonium sulphate applied alone or over 100 mds. of compost per acre. The treatments were applied to the same plots every year. Compost was given to the appropriate plots at the time of preparation of land, and ammonium sulphate was applied as a top-dressing after transplanting. The experiment has been laid out in a split-plot design with compost treatment as main plot treatment and ammonium sulphate levels as sub-plot treatments.

The general conclusions from the experiment were as follows: (1) compost alone gave a response which was lower than the response obtained with ammonium sulphate on equal N basis, (2) increasing the level of ammonium sulphate up to 40 lb. N per acre increased yield when there was no basal dressing of compost but when applied over compost as basal dressing the maximum yield was reached at a dose between 20 and 40 lb. N of ammonium sulphate per acre. The yield decreased when the nitrogen level was 60 lb. N per acre, the rate of decrease being more when there was a basal compost dressing. The effect of nitrogen application on various plant attributes was also studied on random sample basis.

(vii) *N. P. K. experiment.*—To determine the suitable combinations of the three main fertilizing elements, N, P and K and to find their relative performance with the basal-dressing of various organic manures, an experiment was conducted to study the effect of various treatment combinations on the soil fertility and the crop productivity. The fertilizers were tested at three levels of 0, 20, 40 lb. of N, P_2O_5 and K_2O and the organics were applied to supply about 20 lb. N per acre. The organic manures tested were groundnut cake, compost and green manuring by *dhaincha*. The layout used was a split-plot with confounding of the sub-unit treatments. The main plot treatments were the three organic manures and no manures while the sub-plot treatments were 27 treatment combinations of N, P, K. Two degrees of freedom for the N, P, K interactions were confounded in both the experiments.

The main findings were :—

- (1) On equal nitrogen basis 20 lb. N per acre, ammonium sulphate, groundnut cake and green manuring with *dhaincha* were of equal value while compost gave a lower response.
- (2) Where either green manure or groundnut cake was used to supply about 20 lb. N per acre further application of an inorganic fertilizer like ammonium sulphate was not necessary, but with application of compost additional dose of ammonium sulphate was useful.
- (3) Neither phosphate nor potash gave any response when applied either alone or in combination with nitrogenous fertilizers or manures.

(viii) *Effect of manuring on the nutritive quality of rice.*—To study the effect of manure and fertilizer application on the nutritive value of rice, representative grain samples from various treatments were analysed for their thiamine (Vitamin B) contents at the Biochemical Laboratory of the Indian Institute of Science, Bangalore, and the results are presented below :

Thiamine contents : Microgram per gram

Ammonium sulphate N level	No compost	Compost (100 mds. per acre)
0	2.48	2.90
20	2.61	2.90
40	2.63	2.91

The thiamine content of rice obtained from the manurial plots was higher than that in rice from unmanured plots. Therefore, nitrogen application besides increasing the grain yield, also increased the nutritive value of rice. The compost was more effective in the latter respect than ammonium sulphate. More comprehensive work on this aspect is necessary.

(ix) *Cultural-cum-fertilizer experiment*.—A four factor experiment, comprising of the three levels of nitrogen, viz., 0, 20, 40, lb. N per acre, three planting dates and three spacings, viz., 6", 12", and 18" was conducted with three varieties of different maturity periods. N was applied as ammonium sulphate at the time of transplanting. The planting dates were 24th July, 12th and 31st August and 30 days old seedlings were planted in every case. Two out of the four replications were spoiled due to continuous flooding of the fields and had to be rejected.

The first two plantings did not show any significant difference while the last planting on the 31st August gave significantly lower yield, the reduction being to the extent of about 28 per cent.

The application of ammonium sulphate gave an increased yield, there being no significant difference between the two levels of nitrogen.

The closest spacing of 6" had given the highest yield, a result in conformity with the previous year's results. With higher spacings, the decrease in yield showed linear trend.

D.—SECOND CROP EXPERIMENTS.

(i) *Varietal-cum-sowing date experiment*.—This experiment was conducted with the object of (i) finding out suitable varieties to be grown as second crop and (ii) the optimum time of growing the second crop. Six varieties of 105—115 days duration were sown at fortnightly intervals beginning from 1st September immediately after the harvest of early maturing varieties of the first crop. The seedlings were transplanted when they were 30 days old. It was noticed that growth of seedlings in nursery was stunted and unhealthy for the first four sowings. The general conclusions were (1) the plantings done earlier than December were a failure or gave very low yields due to insect and disease attack, (2) that the optimum time of planting is second fortnight of December (from the nursery raised during the later part of November). Transplanted crop gave a higher yield than broadcast, and the variety Ptb.10 gave the best performance in both the years, giving an average yield of 1789 lb. The Chinese varieties Ch.2, Ch.45 and Ch.47 gave relatively better yields when transplanted, but in Ptb.10, Co.13 and DI.4, there was no significant difference between two cultural methods, viz., transplanting and broadcasting.

(ii) *Sequence of cropping*.—(a) Three sequences as mentioned in the table below, were tested with varieties "Benibhog", T.1145 and Ptb.10. The first two were used as first crop varieties and Ptb.10 was used as the second crop variety. The second crop was manured

with ammonium sulphate at the rate of 100 lb. ammonium sulphate per acre. The results are given in table.

TABLE

Treatments : 1st crop	2nd crop.
T ₁ short duration rice (Benibhog)	Short duration rice (Ptb. 10).
T ₂ short duration rice followed by green manuring.	Do.
T ₃ green manuring—Medium duration of rice (T. 1145).	Do.

Yield in lb. per acre

Crop	Treatment	T ₁	T ₂	T ₃	C. D. at 5% level
1st crop		1466	1487	1482	Not significant
2nd crop		1445	2025	1554	63
Combined 1st and 2nd crop		2911	3512	3036	227

The combined yield of the crops was significantly higher in treatment T₂ (short duration rice—green manuring—short duration rice) and there was no significant difference between the other two treatments.

(b) An experiment was conducted to study the effect of groundnut crop on the subsequent rice crop. The second crop of rice following groundnut gave a yield of 1783 lb. per acre as compared to 1296 lb. in the rice following rice. Thus a significant increase in yield to the extent of 38% was obtained by including groundnut in the cropping sequence of rice. The experiment will be repeated to confirm the results.

(iii) *Manuring the second crop.*—To study the response of second crop to manuring, a manurial treatment consisting of a basal dose of 100 mds. of compost supplemented by 20 lb. of N as ammonium sulphate per acre was tried in comparison with no manure as control both under broadcast and transplanted conditions with five varieties. The magnitude of response to manuring was the same both for broadcast and transplanted crop and the overall increase of 316 lb. of paddy was obtained for manurial treatment over the average yield of 1112 lb. obtained in case of unmanured control plots, thus giving an increase of nearly 20 per cent.

STATISTICS

(1) EFFICIENCY OF FIELD LAYOUTS.

(a) The coefficient of variations and block efficiencies obtained in the various field experiments conducted at the Institute were calculated. In these trials the plot sizes varied from about 1/10 to 1/1000 acre and number of plots per block varied from 2 to 18. The coefficient of variation ranged from 6 to 10 per cent. depending on the size of plot and number of plots per block. Block efficiency of randomised block layouts ranged from 1.06 to 2.90, the higher block efficiency being obtained with fewer plots per block. It may be mentioned that C. V. obtained in these experiments were about 50 to 100 per cent. more than those obtained in the uniformity trial conducted in the previous season.

(b) Gain in information on sub-treatment comparisons in split-plot layouts ranged from 6 to 20 per cent.

(c) Lattice layouts such as double, triple, quadruple and balanced two dimensional lattices and cubic lattice with varieties ranging from 25 to 125 in number and plot size varying from $1/255$ to $1/1498$ acre, were compared with randomised block layouts and it was found that no gain in information resulted from adopting the lattice layouts, a result in conformity with previous year's findings based on uniformity trial data.

(2) CORRELATION STUDIES.

Inter-varietal correlations between yield and number of earheads and between yield and plant height were found to be 0.52 and 0.47 respectively in a varietal trial with 36 varieties of 90 to 110 days duration. Significant partial correlations of yield with these two characters were also found. However, ear-length was negatively correlated with the number of earheads. The multiple correlation 'R' for regression of yield on ear number, ear-length and plant height was 0.6406, while without ear-length it was 0.6370, thereby indicating that there is practically no reduction in the accuracy of the estimate of varietal yield by the omission of ear-length. The fact that the multiple correlation was not high indicates that other characters such as grain weight and density are important contributory factors in the estimation of varietal yields.

(3) DISCRIMINANT FUNCTION.

Investigations were made on the use of discriminant function based on yield components such as earhead number, grain weight and number of grains per ear, for varietal selection. The results indicated that the discriminant function was not more efficient than straight selection based on yield alone. Among the yield components, the maximum weight in the discriminant was given by earhead number and least by number of grains per ear.

(4) SAMPLING STUDIES.

(a) *Sampling variance and size of plot.*—The sampling variance per unit sample of $4' \times 4'$ was found to increase with size of plot for both yield and tillers, the relationship of sampling variance to plot size being of the form $Y = ax^2$ where Y is sampling variance per unit and x size of plot.

(b) *Effect of different factors on sampling variance.*—Sampling variances of single plant height and number of earheads per plant were worked for plots treated differently. It was found that manuring and time of planting did not affect the sampling variance, but increased spacing not only increased mean earhead number per plant, but also the corresponding sampling variance.

(c) *Sampling studies on gall fly and steam-borer.*—The data from different experiments in which sampling observations were taken on these pests were utilised to find out the efficiency of samples and the number of samples per plot necessary for estimating these pest incidences with a given level of accuracy. The sampling unit adopted in these experiments was $2' \times 2'$. It was found that as far as gall fly incidence was concerned, the amount of information obtained with sampling fractions from 4 to 7 per cent. varied from 50 to 65 per cent. and the S. E. obtained with 4 replications was about 4 to 6 per cent.

With plot sizes ranging from 200 to 300 sq. ft. and with 8 to 10 plots per block about 2 samples per plot was sufficient to estimate mean values with about 6% S. E. The minimum number of samples necessary for other levels of accuracy and varying number of replications were also worked out. The number of samples necessary for a given level of accuracy was higher for stem-borers than for gall fly. In both cases, the non-sampling portion of the error variance, viz., true plot variance was much smaller than sampling variance within a plot. The ratio of sampling to plot variance was higher for borer incidence.

(d) *Distribution of stem-borer incidence in rice.*—By dividing a field of 32' × 134' growing a bulk crop into 8 concentric rectangular regions and taking a number of 2' × 2' samples from each such region for examination of stem-borer incidence, it was found that the incidence was highest at the outermost region and was less towards the central area. In the successive regions towards the centre, the incidence decreased only upto about 32' from the periphery and thereafter remained practically same. The sampling variance within each region was, however, practically same for all regions indicating thereby that the best method of sampling for borer incidence in bulk fields will be to stratify the field into regions according to the distance from the bunds and distribute the total number of sampling units in proportion to the size of stratum.

(e) *Multistage sampling.*—Multistage sampling with stratification was used to estimate the degree of blast (*Piricularia oryzae*) incidence in field experiments. The primary units were 2' × 2' square and secondary units were random plants within the square. The components of variance for different stages were calculated and it was found that taking due account of labour and time involved, the optimum sampling procedure was to take only three secondary units from each of the primary units. Stratification of the plots did not give any appreciable increase in accuracy.

Multistage sampling was also adopted to determine in the laboratory the thickness of bran layer in sections of grain, the different stages being grains, sections within grains and readings within sections. The components of variation for each of these stages were calculated and it was found that the optimum sampling procedure was to take only two sections and two observations per section. In general about 15 grains were found to be necessary for obtaining 4% S. E. The S. E. of the mean varied from variety to variety to a certain extent and the above sample size is only approximate.

(5) ASSESSMENT OF ADDITIONAL PRODUCTION IN CULTIVATOR'S FIELD RESULTING FROM APPLICATION OF AMMONIUM SULPHATE.

Under the 'Grow More Food' campaign in Orissa State, one of the Intensive Cultivation Centres of 5,000 acres comprising about 20 villages in the neighbourhood of the Institute was under the charge of the Institute. Due to lateness in the season when the work was taken up in July 1950, it was decided to demonstrate on a large scale, the utility of applying ammonium sulphate to rice at the rate of 100 lb. per acre to supply 20 lb. of nitrogen, and assess the increased production that might be expected.

The sampling procedure was to choose at random a pair of adjacent or neighbouring fields belonging to a beneficiary of the aid. Such field pairs were chosen from 70 growers out of a total 120 beneficiaries. From the selected pair of fields, one was randomly chosen for receiving manures and the other was left as the control. Care was taken to see that the pairs were similar in all other respects, such as variety, cultural practice, previous manuring, if any, etc. The fertilizer was applied when the crop was about 6 weeks to 8 weeks old at the time of "beushening" in the broadcast fields and at the time of weeding in the transplanted fields. The final yield figures were determined from a random sample of $16\frac{1}{2}' \times 16\frac{1}{2}'$ from the manured and control fields. The results obtained are given below:—

Plot	Yield lb. per acre
Control	1521
Manured	1796
S. E. of mean yield	63.6 lb.
Response per acre	275 lb.
S. E. of response	89.93 lb.
No. of experiments	61

The manured plots have on the average given about 18% increase of grain yield over the control. The average response for the standard dose of 20 lb. nitrogen is 275 lb. per acre. This additional grain yield together with additional yield of 6-7 mds. straw brings a reasonable profit to the grower.

BOTANY

I. MAINTENANCE AND STUDY OF GENETIC STOCKS INCLUDING WILD RICES.

From the various places in India and abroad two hundred and thirty-nine samples of cultivated and wild rices were received. Five hundred and ninety-six seed samples were supplied on request to foreign countries as well as to the different States of India. The Institute has now got ten out of the twenty-one species known in rice. The collections of *O. sativa* var. *fatua* received during 1948-49 from various sources in India were grown and it was found that all the samples except those from Cochin were natural hybrids between *fatua* and the cultivated rice. It was possible to isolate from the progeny plants which resembled closely both the cultivated rice and also the wild rice with a range of intermediate types differing in plant habitat, panicle characters, degree of shatterings, etc. Information regarding the description of genetic stocks collected from different states of India was compiled for the Catalogue of World Genetic Stocks of Rice published by FAO.

II. IMPROVING RICE YIELDS BY:

(a) *Introduction*.—After studying various agronomic characters of the varieties in the Genetic Stock collection, preliminary yield trials were conducted to isolate high yielding varieties. Out of four hundred and seventy-six types tested during the two years, thirty-one types were carried forward for trials during the next season. Of these, seven among the medium duration varieties did consistently better over the standards T.1145 and T.812 in both the years. In the varieties of 155 days duration only one T.1902 proved superior to the standards T.90 and T.1242.

(b) *Selection*.—Experiments were conducted during the period under report to find out whether genetic variability was present in established strains and if so whether it could be exploited to push up yields of rice varieties by further selection. In this connection the selections brought forward from previous year's trial were tested and new materials were obtained by selection from some important provincial strains.

Two hundred and fifty random earheads in Co.14, Co.19, Geb. 24, Adt.4 and Adt.20 were selected for study of genetic variability. The number of grains, length and weight of panicles and weight of 1000 grains were recorded for all the five varieties.

No genetic variability was found when 96 single earhead selections made in 1948-49 of 'Benibhog' were tested in a replicated progeny row trial. However, this result needs confirmation by further tests, as the S. E. in the above experiment was high (11%) and the replications were restricted to four owing to want of sufficient seedlings. In similar trials carried out with materials from Co.14 significant genetic variability was found.

Test of significance from Co.14 trial.

Mean yield per plot (oz.)	Total variability	Genetic variance	% of genetic variance to total variance	% C. V. due to genetic variance
4.4	0.4578	0.2834	61.9	11.7

On the basis of yield performance, ten best progenies with six best plants in each from Co.14 were carried forward for further work.

Secondary selection trials were continued for the two years in the variety T.1222-12 with materials brought forward from 1948-49. Significant differences were found within the family tested in 1949-50 and in the trials conducted in 1950-51, families were composed of the two best progenies of 1949-50, families with six best plants in each. There were thus two sub-families in each family with six progenies in each. The mean yields of the families are given below:—

Family No. (1949-50)	116	133	107	127	128
Mean yield of 2 best progenies (in oz.)	12.47	11.93	12.37	10.97	10.5
Mean yield of families (in oz.)	10.68	10.21	10.87	9.91	9.9
Difference	1.79	1.72	1.50	1.06	0.79

It would be seen that the difference between the mean yield of the selected progenies and the family mean was maximum in case of family 116, followed by family 133. The family comparison further showed that there were no significant differences between the two sub-families of a family, which is in conformity with the results of 1949-50. In the within-family comparison, significant differences were still found between progenies in the two sub-families of family 116, viz., 116-30 and 116-88. This showed that genetic variability existed even after three years of continuous selection. There was still scope for further selection in this family.

Further secondary selection trials were conducted with materials brought forward from the rice varieties T.897, T.642-11, T.56, T.1242 and FR.43-B. Significant differences between families were found in T.897 only. In this variety families 457 and 482 gave significantly superior yields over rest of the families of the variety. But these materials were not subjected to further selection as there was no significant variability within the two best families mentioned above. However these were carried forward for bulk trials.

Side by side with selection trials mentioned above, parallel yield trials with the family bulks were also conducted. No significant differences were found between family bulks in the varieties, T.1242, T.56 and FR.43-B. In T.897 the bulk of family 457 yielded 23.6% more than the original bulk. In 1222-12 the following five families, 106, 116, 127, 128 and 133 were studied. The worst and the best progeny bulks of each family were included. Their performance in the yield trial is given in the following table:—

Table showing the mean yield per plot in lb. obtained in comparison of superior vs inferior bulks.

Plot size—6' × 15'					Replications—6		
Family No.					Superior	Inferior	Family mean
107	.	.	.	.	3.10	2.72	2.91
116	.	.	.	.	3.16	2.86	3.01
127	.	.	.	.	3.24	2.73	2.99
128	.	.	.	.	3.00	2.82	2.91
133	.	.	.	.	3.39	2.86	3.13
Mean for the group					3.18	2.80	

It will be seen that in all cases the superior bulks were better than the inferior and on an average, the superior bulks yielded 13.5% higher than the inferior bulks, the increase being significant.

Selection at two levels of fertility.—In order to see whether selections made under different levels of soil fertility would yield strains suitable for different conditions, selections were made in two cultivated bulks, viz., *kankesal* and *chinnamali* (of about 135 days duration) growing under normal and low fertility conditions. The normal fertility treatment consisted of green manuring as compared to no manuring. 550 single plant selections based on the number of ear-bearing tillers were made in 1949-50 in each of the two levels in each variety and finally 100 best plants were selected in each level on the basis of single plant yield. These were grown in 1950-51 in a progeny row trial, with six replications, under the 'normal' and 'low' fertility soil conditions. During this year the normal fertility plots received 40 lb. N (as ammonium sulphate) per acre in the place of green manure while the low fertility plots remained unmanured. There were two separate trials for the two varieties.

The mean yield per plot in oz. of ten of the high yielding, low and normal fertility selections under the two treatments (i.e., manured and unmanured) is given below:—

L. F. selections						N. F. selections					
Rank under-manured	Pro-geny No.	Manu- red (N.F.)	Un-manu- red (L.F.)	Rank under-unma-nured	Increase over un-manured	Rank under-manured	Pro-geny No.	Manu- red (N.F.)	Un-manu- red (L.F.)	Rank under-unma-nured	Increase over un-manured
1	41	6.15	3.94	13	2.21	1	61	6.08	4.72	4	1.36
2	5	6.09	3.98	9	2.10	2	48	5.86	4.66	7	1.20
3	31	6.00	4.05	5	1.95	3	96	5.68	4.48	9	1.20
4	35	5.88	3.96	11	1.92	4	24	5.26	4.86	2	0.40
5	85	5.86	3.89	15	1.97	5	55	5.26	4.82	3	0.44
6	39	5.54	3.95	12	1.59	6	36	5.22	4.42	11	0.80
7	28	5.49	3.90	14	1.59	7	31	5.20	4.32	14	0.88
8	29	5.45	4.48	1	0.97	8	80	5.01	4.56	8	0.45
9	83	5.38	4.02	6	1.36	9	72	4.98	4.89	1	0.09
10	12	5.36	4.10	4	1.26	10	95	4.98	4.44	10	0.54
Mean of L. F. progenies		5.57	3.49			Mean of N. F. progenies		4.91	3.93		
Bulk		4.75	3.14			Bulk		4.75	3.14		
C. D. at 5%			1.12 oz.			C. D. at 5%			1.17 oz.		

The ranking of progenies in manured and unmanured plots are somewhat different, i.e., the progenies which have done better under manured conditions have not maintained the same superiority under unmanured conditions. However, the interaction of progenies with manuring is not significant in normal fertility selections and is only just significant in L.F. Selections. Therefore, differential response of progenies to manuring can be ascertained only by future tests.

Thirty-five progenies from each of the normal and low fertility selections were selected on the basis of average ear-bearing tillers per plant from both levels of fertility put together and carried forward for further trial next year.

(c) Hybridization.—

(i) *Hybridization between indica and japonica.*—Two geographical races of the species *O. sativa* are recognised—the *indica* cultivated in the tropics and the *japonica* in the sub-tropics, i.e., in Spain, Italy, Japan, Korea and U.S.A. The two groups of rices have their own inherent characteristics. The *japonica* group though giving more than double the average yield of the *indica*, about 2500 lb. per acre does not do well under the tropical conditions. It responds to intensive manuring and does not lodge unlike the *indica* group in the tropical habitat. The *indica* group, on the other hand, is more hardy and several of them carry genes, responsible for resistance to some of the most important diseases. Under the auspices of the FAO a programme of hybridization between the two groups of rices has been started at the Institute in which India and eight South East Asian countries, viz., Burma, Philippines, Thailand, Indo-China, Indonesia, Malaya, Ceylon and Pakistan are participating. These countries have selected 33 *indica* parents to be crossed with 8 *japonica* parents received from Dr. Morinaga of Japan. It is proposed to supply the seed raised from

the crosses (F_1) to the participating countries which will grow and select from the F_2 generation onwards for evolving superior strains suited to their climatic conditions. Likewise, for the benefit of rice growing regions in India, a similar hybridization scheme has been started with a grant from Indian Council of Agricultural Research. In this, 16 rice growing States of India have each selected two of their local *indica* strains for crossing with 6 *japonicas* at Cuttack. The seeds from F_1 s will be sent out to the States for raising F_2 s and for selecting under their climatic conditions.

The crossing work under the FAO Scheme was initiated in 1949-50 and by 1950-51, 5,200 hybrid seeds were obtained. The work in connection with the I.C.A.R. Scheme for Indian States was started in 1950-51 season only.

As the *japonicas* flowered within 75 days of sowing and all the *indicas* were much later in duration, the following methods were tried to get them flower at the same time for carrying out the hybridization programme:—

- (i) the *indicas* were sown earlier and the *japonicas* later.
- (ii) short day treatment of 8 hours light was given to *indicas* when the plants were 5 weeks old. The response obtained by this treatment depended upon the normal duration of the types concerned. The flowering was hastened by 12 days when compared to the normal in early types; it was hastened by 40 days in the case of medium duration types and by 70 days in the case of long duration types.
- (iii) growing *japonicas* under hot house conditions during winter. Such treatment enables the *japonicas* to grow well and produce viable pollen.

(ii) *Hybridization within indica group*.—A programme of hybridization within *indica* group was undertaken to combine earliness and high yield within *indica* group. For this purpose, some of the very early types of 80–100 days duration including Chinese types were crossed with established high yielding late duration varieties and about 500 cross-seeds obtained. In the F_1 generation there was definitely hybrid vigour (heterosis). The hybrids were all much earlier in flowering than the late parents and had a larger number of ear-bearing tillers and gave a higher single plant yield than the mean of two parents.

IV. GENETICS OF PIGMENTATION, GRAIN, SIZE AND OTHER CHARACTERS.

(i) *Pigmentation*.—Investigations were undertaken with a view to determine the number, role and inter-relationship of genes responsible for pigmentation and to determine pigmentation patterns if any in rice.

F_1 generation.—In the F_1 plants the pigmentation of leaf sheath was generally intermediate between the two parents in intensity, i.e., the pigmentation was less than that in the higher grade parent but more than that in the lower grade parent. In crosses involving the parent with dark purple leaf blade, the F_1 hybrid had a green leaf blade and in other organs like auricle, ligule, etc., the pigmentation was diluted. In hybrid between a type with green leaf blade and one

with purple wash the purple wash was very much diluted quite unlike the pure green colour of the hybrid between green leaf blade type and one with deep purple leaf blade. The F_1 s involving T.636, an entirely green plant, and other green parents, the following 3 types of plants with different pigmentation patterns were obtained: Pigment was confined to (i) glume, apiculus and stigma, (ii) leaf-sheath, glume, lemma and palea, apiculus and stigma, (iii) leaf-sheath, ligule, junctura, L. axil, septum, glume, lemma and palea, apiculus and stigma.

F_2 generation.—Twenty-three F_2 families were classified and while the full interpretation of the data remains to be done the following conclusions could be tentatively drawn:—

- (i) There are two basic pigmentation genes, the absence of either or both results in a green plant.
- (ii) There are two or more genes which control pigmentation in various parts and the same gene may be causing pigmentation in a number of parts.
- (iii) There are independent genes causing the deep purple and purple wash in the leaf blade and the latter are epistatic to the former.

Natural hybrids—*Balunga mardan*.—14 single plant cultures from this deep purple type were found to be segregating into four classes, viz., deep purple leaf blade, green leaf blade, albinos and pink plants which were called pink albinos. The last two categories of plants died in the seedling stage. Albinism was found to be governed in this material by a single gene, so also, purple-green difference. The pigmentation and albinism genes were found to be independent of each other. When the seeds from some green plants found in a plot of *Balunga Mardan* were collected and sown, the progenies gave a segregation ratio of 13 green : 3 deep purple indicating the presence of an inhibitor gene governing the expression of purple in the green parent type.

(ii) **Grain size.**—The F_1 material from crosses have been carried forward and further crosses necessary for the work were made. The F_1 s, F_2 s and F_3 s will be grown together for the study of this quantitative character.

(iii) **Auricle and glume.**—Most of the rice varieties have a well developed auricle. A few varieties in the collection have rudimentary auricles. In glume length there is also variation. Crosses were made for investigation of these characters.

V. MISCELLANEOUS—BRAN LAYER AND NUTRITIVE VALUE.

The thickness of the bran layer in rice grain is generally considered to be positively correlated with protein and thiamine contents in rice but this has yet to be established. A correct method of estimating the bran thickness has also yet to be evolved. With this view histological studies were taken up. All the glutinous rices examined showed a patch of cellular structure in the spermoderm which gave a positive test for protein. The size of the patch, however, varied, the dark purple glutinous rices had larger patches than the white glutinous rices. Such a patch was either not present at all in white non-glutinous rices or if present, was of extremely small size, while in coloured non-glutinous rices, a small patch was invariably present.

CHEMISTRY

Owing to the absence of full laboratory facilities, the work of the section was confined to small scale field experiments, in some of which, useful results were obtained.

I. *Seed soaking in nutrient solutions.*—Experiments were conducted to study if crop yield could be increased by soaking of seed in solutions of different mineral nutrients, prior to sowing. In preliminary experiments conducted in the previous years, treatment of seed with solution of potassium phosphate had given promising results. Experiments were therefore continued and following mineral salts and other treatments were tried during the two years under report.

- | | | |
|---------------------------------------|----------------------------------|------------------------------|
| 1. KH_2PO_4 | 2. K_2HPO_4 | 3. K_3PO_4 |
| 4. $\text{NH}_4\text{H}_2\text{PO}_4$ | 5. $(\text{NH}_4)_2\text{HPO}_4$ | 6. NaH_2PO_4 |
| 7. Na_2HPO_4 | 8. $(\text{NH}_4)_2\text{SO}_4$ | 9. NH_4NO_3 |
| 10. Cattle dung paste | 11. Cattle urine | 12. Water soaking |
| 13. Untreated control | | |

All mineral salts were used at three concentrations, 2M, M and M/2 each, dissolved in water. The seeds were soaked in one-third of their weight of respective solution for 24 hours and sun dried before sowing. This 3:1 ratio of seed to solution was used as any quantity of solution above this remained unabsorbed by seed during 24-36 hour soaking period. A variety of paddy T.608 was used during both the years and seed was directly sown in lines 9" apart in a replicated trial, with and without a basal dressing of sulphate of ammonia to supply 20 lb. nitrogen per acre.

Treatments generally effected the germination of seed and stand of the crop in plots sown with soaked seed was about 10% to 15% lower than the control plots. During both years, treatment of seed with chemical K_2HPO_4 gave significantly higher yields of grain than control; different chemical concentrations were, however, not significant, nor was their interaction with nitrogen significant.

Yield of grain in lb. per acre.

	Control	K_2HPO_4 treatment
1949-50	830	953
	% 100.0	114.8
1950-51	746	874
	% 100.0	117.1

Soaking of seed in M/2, M/4 and M/8 solutions of Manganese sulphate and potassium permanganate was also tried in a separate experiment, but no significant differences were observed due to treatments.

II. *Phosphatic manurial experiments.*—(a) In the previous year, super phosphate and a number of rock phosphates tried at 30 lb. K_2O_5 per acre, gave significant yield increases over control. The residual effect of this phosphatic application was estimated during the season. No residual effect of any kind was observable.

(b) Separate field experiments at different locations were conducted with super phosphate of lime and agrophos, both at 30 lb. P_2O_5 per acre, in combination with lime and sulphate of ammonia. Sub-surface placement of phosphatic fertilizer in the root zone of the crop was also tried. No yield response due to phosphatic fertilization was obtained.

Pot experiments with heavy and medium soil at two levels of super phosphate of lime, 30 lb. and 60 lb. P_2O_5 per acre in combination with lime and sulphate of ammonia were also tried, but no advantages due to phosphatic fertilization, alone or in combination with other fertilizers, could be observed.

III. *Sub-surface (Deep) placement of sulphate of ammonia fertilizer.*—Experiments were conducted to test the efficacy of sub-surface (deep) placement of ammonium sulphate under wet soil conditions, 2-3 weeks after the crop was planted. The requisite quantity of fertilizer was mixed with 5—10 times its weight of soil and made into soft dough with water; this was made into pellets of about an inch in diameter and thrust 2"–3" deep in soil, about 12"–18" apart in between the rows of the transplanted crop. Experiments were conducted both for the *kharif* crop (June–Oct.) and for the second crop (Jan.–April) with the fertilizers at 10, 20 and 40 lb. N per acre. Variety Co. 13 was used in the two seasons.

During both the seasons, sub-surface (deep) placement of fertilizer resulted in relatively higher yields of grain as compared to usual surface application, at all levels of nitrogen and 20 lb. nitrogen deep placed was found to be the economic level. Yield results are given below:—

Yield in lb. per acre

Levels of nitrogen	Kharif crop June–Oct.		2nd crop Jan.–April	
	Surface	Deep	Surface	Deep
No nitrogen . . . %		1747 100·0		1402 100·0
10 lb. N/acre . . . %	..	..	1458 104·0	1553 110·8
20 lb. N/acre . . . %	1882 107·7	2009 115·0	1513 107·9	1781 127·0
40 lb. N/acre . . . %	2035 116·5	2101 120·3	1564 111·6	1798 128·2
C. D. for comparing surface vs. deep.		139 lb.		92 lb.

The increased response makes sub-surface placement more efficient than the customary surface application. Yield of straw and other plant characters, such as ear-bearing tillers and height of plant were also significantly higher for sub-surface placement.

IV. *Liquid ammonia as a fertilizer for rice crop.*—Liquid ammonia applied with irrigation water was tried as a fertilizer for rice crop in a small scale pot experiment and compared with sulphate of ammonia fertilizer, both at 20 lb. and 40 lb. nitrogen per acre. Sulphate of ammonia was found to be superior at both levels. Liquid ammonia gave 16% and 31% increase in yield for the two levels respectively, while sulphate of ammonia gave 37% and 68% increase in yield respectively for corresponding levels of nitrogen.

V. *Boron as a fertilizer for rice.*—An experiment was tried with boron in the form of borax at 5.5, 11, 22, 44 and 88 lb. per acre with and without a basal dressing of sulphate of ammonia at 20 lb. N per acre, with variety of paddy T.1242. Borax on an average gave a yield increase of 7% over a control (no borax) yield of 2429 lb. per acre, there being no difference between various levels of the fertilizer. No interaction between borax and nitrogen fertilizer was observed.

VI. *Hortomone treatment for rice seedlings.*—Soakings of roots of seedlings for 24 hours in 'Hortomone A' (I.C.I.) solution, before planting was tried at concentrations of 1:1,000, 1:10,000, and 1:100,000 of 'Hortomone A' in water. The object was to see, if 'Hortomone A' which is a rooting hormone would help to establish the plants quicker and produce more tillers. No difference was observed between the treated and control seedlings in tillering, growth or yield of the crop.

VII. *Experiments on light and heavy seed.*—In Japan the cultivators usually remove the light rice seeds by soaking the seed in about 18% brine solution prior to sowing, the advantage being that heavy seeds germinate quickly and give added vigour to the seedlings. This was considered particularly important under broadcast conditions, where good and quicker germination may improve the further development of the plant. To see if there was any advantage in growing heavy seeds under broadcast conditions, seeds of two early and two late varieties of paddy were soaked in water and in brine solutions to remove the light floating seeds. The heavy seeds thus obtained were sown directly in lines. In a replicated trial, keeping unsoaked seed as control. Seed rate of 30 lb. per acre was used for all varieties and a seed rate correction was applied for differential weight per 1,000 grains of graded and ungraded seeds. Percentage of light seed in early varieties was found to be greater than in late varieties. Germination count taken under field conditions revealed that for each variety about 45% to 47% of seed dropped in each line germinated, irrespective of treatment. The yield figures did not show any significant differences, nor was there any interaction between treatments and varieties.

ENTOMOLOGY

A—FIELD PESTS.

I. *Varietal susceptibility to gall fly and stem borers.*—With the object of finding out whether scent and pigment in rice varieties have any bearing on the incidence of pests, an experiment was carried out with twelve varieties including scented, deeply pigmented and normal green ones. Samples were taken out at different stages of plant growth. In each sample, the number of healthy tillers, tillers affected by gall fly and borers and the population of insects were noted. At harvest, counts of white ear heads were taken in the samples as well as in all the remaining plants of the plots. On

examination it was found that all the white ear heads were not due to borers and they were classified into (i) those due to borers and (ii) those due to other causes. The highest incidence of borer attack from the count of white ear heads was recorded in T.412 and the lowest in G.E.B.24 and the varieties in the order of susceptibility are given below.

T.412, CP.9, T.1242, T.812, CP.6, FR.43-B, T.90, AKP.11 and G.E.B.24.

Significant differences were found between the varieties in their susceptibility to gall fly. The varieties are given below in the ascending order of incidence of gall fly. CP.9, Jeerasala, Jeeragasamba, CP.6, Basumati, T.412, T.1242, T.812, AKP.11, T.90, FR.43-B and GEB.24. Of these CP.9 and CP.6 are pigmented while T.412, Basumati, Jeeragasamba and Jeerasala are scented. In general pigmented and scented varieties were less affected by gall fly.

There were significant differences between the varieties in total number of tillers per plant. The varieties more affected by gall fly had a greater number of tillers. The inter-variatal correlation between tillering and percentage attacked by gall fly is +0.651, which is significant. Whether it is the pigment or scent or the poor tillering capacity of certain varieties that make them less affected by gall fly, needs further critical examination.

II. *Date of planting and its relation to incidence of gall fly and stem borers.*—With the object of determining whether the incidence of the pests depends on the age of the crop or the time of planting two varieties CH.45 and DI.4 were planted at fortnightly intervals. Twelve plantings were done in all beginning from 24-7-50 and ending on 9-1-51. Seed-beds were raised every fortnight and seedlings transplanted 30 days after sowing.

Observations on tillering and the incidence of gall fly were taken at two stages, 30 and 60 days after planting. The peak period of incidence was noted to be from the end of October till the end of November and irrespective of the time of the planting 90 days old plants were found more susceptible. The incidence of borer attack was noticed in the beginning of November.

III. *Seedlings treatment against gall fly.*—The object of the experiment was to see whether treatment of seedlings with insecticides would bring down gall fly incidence. Two varieties, one very susceptible (GEB.24) and the other less susceptible (T.412) were taken for this experiment. At the time of planting, the seedlings were immersed for half an hour in water suspension of 0.2% 0.1% and 0.07% of DDT and then transplanted. Counts of total tillers and tillers attacked by gall fly were taken at two stages of the crop, i.e., at 30 days and 60 days after transplanting. None of the treatments had any effect either on the gall fly incidence or yield of the two varieties.

IV. *Further studies on control of stem borer.*—The summer or 'Dalua' crop suffers more loss due to stem borers than the main season crop. The following experiments on borer incidence and control were carried out in the second crop season.

(a) *Insecticidal trials against borers.*—The effect of insecticides on the incidence of borers was investigated with the varieties PTB.10 and DI.4 in the second crop season under manured and unmanured conditions. Seedlings were raised on 2-12-49 and transplanted on 6-1-50. Treatments consisted of mechanical control and spraying the plots thrice with the following insecticides: Guesarol 550, Toxophene, Agrocide and AP/5045. The plots under manurial treatment received ammonium sulphate at 100 lb. per acre. Counts of dead hearts and of white ear heads were made. The white ear heads were split open and classified into those due to borers and those due to causes other than borers. Treatments with insecticides significantly reduced the incidence of dead hearts. Treatments with G.550, Toxophene and AP/5045 gave the lowest percentage of dead hearts in the variety PTB.10, while in DI.4, G.550 and Toxophene gave the lowest percentage. Since the sprayings were not directed against the attack at the flag leaf stage, the percentage of white ear heads was not significantly lower for the insecticides compared with control nor was it significantly different for manurial treatment or for varieties. Treatments with insecticides showed no significant differences with regard to the percentage incidence of white ear-heads due to causes other than borers. Under unmanured conditions, there was no significant difference between varieties but under manured conditions DI.4 showed significantly more percentage of incidence of dead hearts due to causes other than borers.

In both the varieties, Toxophene and AP/5045 gave the highest yield and were significantly better than the control. PTB. 10 gave significantly higher yield with G.550 also. The increase in yield was mainly due to increased number of healthy ear heads. Although the interaction of manure with varieties was not significant, it appeared that PTB.10 responded relatively better to manure than DI.4. The lower response to manuring in DI.4 may probably be due to its having a larger percentage of chaffy ear heads due to causes other than borers under manured conditions.

(b) *Treatment of seedlings with insecticides against stem-borers.*—Dipping the seedlings alone cannot be effective to control the borers for whole of the crop season. This should be followed by spraying the crop at intervals which should coincide with the brood emergence. Laboratory tests conducted proved that 0.1% of BHC is the proper strength that could be used for dipping paddy seedlings without any deleterious effect on the plant and the time of spraying should coincide with the emergence of the broods.

(c) *Varietal susceptibility to stem-borers.*—This trial was conducted with 12 varieties in January—April when usually the borer incidence is very high. Samples were taken out at the time of harvest and the percentage of borer incidence was determined. There were significant differences in the incidence among varieties; the incidence varying from 0.46% to 2.6%. The varieties tested are given below in the order of their susceptibility to borers, SLO.5 being the most susceptible and CH.45 the least.
SLO.5 CO.20, DI.4, NX.60, PTB.10, SLO.16, CO.13, CO.10, PEA, MTU.15, CH.47, CH.45.

Parasite breeding.—A large collection of grubs of *Pachydiplosis oryzae* brought from the field revealed the presence of two Chalcid parasites on them. These proved to be new species and have

been described as *Proleptacis oryzae* and *Telenomus israeli*. Trials are in progress to breed these parasites for biological control of pests. Similar field collections of stem borers revealed the presence of three species of parasites on the eggs of *Schoenobius* of which two have now been identified as new species and are being described. Another new species of parasite was found on pupae of *Argyria* and has been described as *Aprostocetus israeli*.

B. PESTS OF STORED GRAINS.

(i) *Origin of infestation to stored paddy*.—In order to determine the origin of infestation to stored paddy, an experiment was conducted with 10 varieties. The details of the experiment are given below:—

- (a) One lb. grain in each of the 10 varieties was harvested, threshed and immediately kept in a bottle and sealed with paraffin wax.
- (b) One lb. grain from each of the 10 varieties was bottled and sealed after the sheaves have been kept for 10 days on the threshing floor.
- (c) Harvested grains were first stored in the godown after the usual drying and after one month, one lb. grain samples from each of the varieties were taken and bottled up as above.

Periodical examination was carried out on the population of insects in the sealed bottles. It was seen from the data that all the 10 varieties showed infestation of *Sitotroga cerealella* even in treatment (a) above in which the grain was collected from the standing crop in the field indicating that the moth-attack on the grain begins in the field on the standing crop itself.

In order to determine the stage at which the grain was infested in the field, 10 varieties of paddy were selected in the field and random ears in each stage of development—milk stage, dough stage, and ripe stage, were enclosed in paper bags. The ears with the bags were harvested when the grain was ripe and kept in sealed bottles in the laboratory. Periodical examination of the grain showed that the moth attacks the grain mostly at the ripe stage but it also attacks the grain occasionally at the milk or dough stage.

(ii) *Varietal susceptibility of stored paddy to pests and estimation of losses*.—Eleven varieties of paddy were selected and kept in the godown and periodical examination of population of insects was carried out. Mean population of insects per count varied from 6.3 to 20.1. Varieties are given below in the ascending order of mean population per count.

GEB.24, T.412, FR.13-A, T.1145, FR.43-B, T.1242, T.812, B.76, Benibhog, T.608 and Basumati.

The population of insects was highest during the period July-September for all varieties. The percentage of loss of grain due to insect damage varied from 2.18 to 5.8.

(iii) *Store pests attacking differently processed rice*.—This experiment was conducted with variety T.90 to determine the incidence of store pests in differently processed rice kept in the godown and to estimate the loss caused by insects. The differently processed rice

consisted of raw and parboiled rices with either no polishing or different degrees of polishing. Periodical counts of insect pests in all the treatments were taken. It was seen that the raw rice was more attacked than the parboiled rice and the differences within the degrees of polishing were not, however, statistically significant. The percentage of loss of rice due to insects varied from 3.7 to 5.6 in the case of raw rice and from 2.5 to 5.0 parboiled rice.

MYCOLOGY

I. HELMINTHOSPORIUM DISEASE.

(a) *Varietal susceptibility*.—One hundred and forty varieties were selected for their resistance to Helminthosporium disease at the seedling stage in two artificial infection tests conducted during 1949-51 with 358 varieties consisting of selected resistant varieties of 1948-49 trial and other additional varieties.

(b) *Susceptibility of rice to Helminthosporium oryzae in different stages of growth and in different periods of the year*.—An experiment was conducted in pots with a view to test the reaction of rice varieties to *H. oryzae* during the different periods of growth and also to see whether their reaction differs in different periods of the year. Two susceptible varieties, T.1145 and 'Benibhog', were tested during 1949-50 and in the test of 1950-51, in addition to these two varieties, a resistant variety, T.141, was also included. Plants were inoculated with *H. oryzae* in July, August, September and October and on each date of inoculation plants of different ages were available. The data on infection showed that the susceptibility of the varieties increased progressively with advance in age, in all the three varieties in all the tests. The youngest plants showed the least infection and the oldest, the maximum infection, and there was a progressive increase in the intensity of infection from the younger to the older plants. Comparing the different dates of inoculation, the September inoculation produced the highest infection in plants of all ages. Within any age group the variety T.141 had comparatively less infection than the susceptible varieties, T.1145 and 'Benibhog' in all the tests.

(c) *Viability of H. oryzae*.—Studies were undertaken to see whether the fungus remained viable in soil, seed and other plant parts like leaves, stubbles, etc., during the off-season, i.e., from the period of harvest in November-December till the next sowing in June-July. (i) It was found that in stubbles left in the field, the fungus remained viable for four months from November to February, whereas in similar stubbles stored dry in the laboratory in grease paper bags the fungus was viable upto March, i.e., for five months. The fungus remained viable on leaf stored in grease paper bags in the laboratory from January to July 1950. Data on viability of *H. oryzae* carried inside the seed were obtained from the experiment discussed elsewhere, on the effect of relative humidity of storage on the viability of seeds in five varieties of rice. At relative humidities of 10%, 25%, and 50% the fungus remained viable in all of the five varieties tested, throughout the period of test, i.e., May to November. At 75% and 90% R.H. the fungus remained viable from 1-3 months depending upon the variety. But at 100% i.e., over water, the fungus was not viable beyond one

month in any variety. (ii) Sterilized and unsterilized soils were inoculated with cultures of *H. oryzae* in December 1949 and the viability of the fungus was tested at monthly intervals. In sterilized soil the fungus was found to remain viable till August (i.e., for nearly 9 months) after which the study was discontinued. The fungus could not be isolated from unsterilized soil even a month after the soil was inoculated with the fungus. (iii) In sterilized oatmeal-agar media, the fungus remained viable from December till August (i.e., for nearly 9 months) after which the study was discontinued.

(d) *Aeroscope studies on aerial population of spores of H. oryzae.*—The object of this study was to determine whether the conidia of *H. oryzae* are present in the air over paddy fields in different parts of the year, especially in the off-season when there was no crop in the field. Greased slides were exposed in 6 aeroscopes placed at different parts of the farm at weekly intervals and the slides were examined after 24 hours' exposure. Actual counts of the number of spores of *H. oryzae* on a slide were made and tabulated along with average temperature, relative humidity, solar radiation, rainfall, etc., for the week preceding the observation. It was noted that the spores of *H. oryzae* were constantly found in the slides right from the beginning of the test, though the actual number of spores trapped varied from week to week. There was a rapid fall in the number of conidia trapped in the aeroscope slides in July-August season, especially when the days on which the slides were exposed happened to be rainy. During such days, the few conidia that were trapped were found to be germinating *in situ*. The conidia trapped in the off-season, might have had their origin in some other species of gramineae occurring near rice fields.

(e) *Collateral hosts.*—The possibility of secondary infection taking place from other cultivated cereals and from wild grasses was examined both by a search for natural infection amongst the grasses in the farm and by inoculation tests on 15 species of grasses and on 8 millets. One of the grasses, *Echinochloa colona*, commonly found in and around the rice fields, was observed to have generally a large number of leaf spots. Under artificial inoculation, *Echinochloa colona* along with *Setaria glauca* was found to be susceptible amongst the 15 species of grass tested. Amongst the millets, *Zea Mays*, *Setaria italica*, *Echinochloa frumentacea*, *Sorghum vulgare*, *Panicum meliaceum*, *Panicum miliare* and *Euchlaena mexicana* were susceptible.

(f) *Physiologic specialization.*—Four isolates of *H. oryzae*, one from U.P., one from Madras and two from Cuttack were tested on different varieties of paddy. No difference in pathogenicity among the 4 isolates could be detected from the reaction of the varieties.

(g) *Effect of temperature on 'seedling blight'.*—Seedling blight caused by primary seed-borne infection is not met within the main sowing season in June-July but is commonly seen in the second crop sowings in November-January. Therefore in order to study the effect of temperature on development of seedling blight inoculation experiments were conducted during February-March 1950 when the average laboratory temperature was 28-30°C and again repeated in January 1951 when the temperature was 20-25°C. Ten varieties were used in each of the experiments 7 being common to both.

In the first test, when the temperature was 28-30° C, only one variety, i.e., SLO.5 developed infection to the extent of 4 per cent. only. In the second test, when the temperature was 20-26° C, eight of the varieties including five of the first test developed the disease to the extent of 4—24 per cent.

(h) *Effect of treatment of rice seed with cultural extract of H.oryzae.*—This was tested by soaking seeds in cold water extracts of *H. oryzae* and subsequently studying the reaction of the population raised from treated seeds to artificial and natural infection by *H. oryzae*.

(i) *Pot experiment.*—The following dilutions of the extract were used:—undiluted, 1/10, 1/100, 1/1,000, 1/10,000 and 1/1,00,000. Seedlings raised from seeds soaked in the different dilutions along with untreated seedlings were artificially infected and the infection developing in the seedlings under the different treatments was scored and analysed.

In the susceptible varieties, PB.9, DCA.2 and DCA.12, DCA.14, T.412 and SLO. 3, significantly lower infection than the control was obtained in one or other of the dilutions tested. In the variety SLO.5 (susceptible), where the difference between the treatments and the control was not significant, dilution 1/100 had the lowest infection. In the resistant varieties PTB.10 and PTB.11, GEB.24 and MTU.2, none of the treatments was associated with significantly lower infection than the control.

The regression of the treatments on infection in varieties PB.9, DCA.2 and DCA.12 was found to be quadratic and the best dose (calculated statistically) was between dilution 1/100 and dilution 1/1,000, varying from variety to variety.

In the above experiment, it was found that boiling the extract attenuated its effect of modifying the reaction of the varieties.

(ii) *Field experiment.*—The seeds of the varieties GEB.24, T.90, T.412, MTU.2, SLO.3 and PTB.10 were soaked for 24 hours in the following dilutions of the fungal extracts:—undiluted, 1/10, 1/100, 1/1000, 1/10,000 and sown in seed-beds and seedlings were transplanted. Observations on disease incidence were recorded on 5% of the population in 2 varieties, T.412 and PTB.10, before harvest. In T.412, significantly lower leaf infection than control was obtained in the dilutions 3, 4 and 5. Differences in grain spot were not significant. In variety PTB. 10, though the degree of infection was lowest in the control, differences due to treatment of seeds were not significant either in leaf or grain infection. In yield none of the 5 treatments differed significantly from the control in any of the varieties.

II. BLAST DISEASE OF RICE.

(a) *Varietal susceptibility.*—Two artificial infection tests were carried out during the period under report with seedlings grown in pots and manured with Ammonium Sulphate at

the rate of 20 lb. N per acre. On the basis of the two tests with 441 varieties 320 varieties were rejected as susceptible and 121 varieties carried forward for further tests on their resistance.

(b) *Effect of fertilizer application on the incidence of blast.*—

(i) Observations were recorded in two experiments of the Agronomist with a view to determine the relationship between the level of nitrogen and blast incidence. In the first experiment there were 5 levels of nitrogen 0, 20, 40, 60 and 80 lb. per acre applied as ammonium sulphate, with or without 100 mds. of compost for each level of inorganic nitrogen. The variety was T.1145. Detailed plot to plot observation on the disease incidence was made by suitable sampling. On analysis it was found that though the plots which had received compost showed slightly higher infection than those which had not received any, over all the 5 levels of inorganic nitrogen, the difference was slight and insignificant. With the 5 levels of inorganic nitrogen, however, the incidence of blast showed a highly significant linear relationship, the severity of incidence increasing proportionately to the increase of nitrogen levels.

In the second experiment in which observation on blast incidence was taken, basic organic dressings of compost, groundnut cake and *Dhaincha* were tested in combination with inorganic nitrogen, phosphate and potash. The variety was T.1145. The disease incidence in basal dressing of different organic manures alone was very slight but in the treatments with ammonium sulphate there was significant effect. As in the previous experiment, the entire effect of ammonium sulphate was linear. The interaction of nitrogen with basal dressings of organics and with phosphate and potash factors was not significant. This indicated that the increase of incidence of the disease due to application of ammonium sulphate was almost the same irrespective of the presence or absence of basal organics or phosphate or potash.

- (ii) In order to find out the relation between the blast incidence and the level of nitrogen applied in the case of varieties differing in their susceptibility to blast disease, seedlings of 9 varieties were raised in pots under 6 levels of nitrogen, i.e., 0, 20, 40, 60, 80 and 100 lb. of nitrogen per acre and artificially inoculated with spore suspension of *Piricularia oryzae*.

Broadly speaking, the nine varieties tested fell into 3 distinct reaction groups with reference to the incidence of blast under the 6 levels of nitrogen. On one extreme was CO.4 whose resistance was scarcely altered by nitrogen levels even upto 100 lb. per acre, though a slight increase in the amount of infection was noticed from one level to another. On the other extreme were the two varieties, ASD.1 and CO.13 in which the amount of infection increased steeply with increasing dose of nitrogen. In between these two groups was the

reaction of the other 6 varieties. But even within these 6, the increase in infection in T.141 and T.608 was not as great as was noticed in the remaining 4 varieties.

- (c) *Loss caused by blast and control.*—Blast appeared in 6 fields of the variety, CO.13, covering 2 : 4 acres. It was apparently more severe in 2 of the fields which had received 20 lb. of nitrogen as ammonium sulphate, in addition to the common basal dose of farm-yard manure at 10 cart-loads per acre for all the fields. Beginning from 17-9-50 till 11-10-50, the fields were sprayed with bordeaux mixture of 5:5:50, strength at the rate of 100 gallons per acre at weekly intervals. Suitable unsprayed control plots were maintained. It was found that by spraying the loss caused by the disease could be minimised. There was an increase in yield of 37 per cent. over the control plots (increase of 435 lb. of grain over an yield of 1,165 lb.). In the other 4 fields, though the increase was much less, the yield was significantly higher in the sprayed as compared to the unsprayed plots.
- (d) *Physiologic specialization.*—Cultural studies of 5 isolates of *Piricularia oryzae*, 2 from Cuttack and one each from I.A.R.I. (New Delhi), Coimbatore and Wynad (Madras) showed slight variations in colour and amount of aerial mycelium. Inoculation studies on seedlings of a number of rice varieties showed no specialization in the pathogenicity of the isolates.
- (e) *Age of crop in relation to incidence of blast.*—In one of the farm experiments for determining the optimum time of planting for the variety, T.1145, there were 5 planting dates beginning from July 20th and ending with August 29th with 10 days interval between 2 plantings. On 29-9-50 when considerable amount of leaf infection had appeared, observations were taken on the incidence of blast on plants, the age of which varied between 62 and 112 days on this date and it was found that the younger the plant, i.e., the later the planting, the greater was the incidence of the disease. Subsequent observations on the incidence of neck infection did not, however, show such significant difference among the different planting dates.

III. GRAIN SPOT AND SEED TREATMENT OF RICE.

During the period under report studies were continued on (1) susceptibility of varieties to spotting, (2) loss in germination and yield caused by spotted seeds, (3) the effect of seed treatment on germination and yield, and (4) pathogenicity of grain-spotting organisms.

(1) *Varietal susceptibility to spotting.*—Three hundred and eighty-eight varieties including 245 tested in 1948-49 were examined for grain-spotting. The data which are in conformity with those previously obtained showed that in early varieties in which flowering coincided with the late monsoon the average incidence of spotting was very high; the incidence of spotting became less with later varieties upto a duration of 160 days. In varieties beyond this duration the incidence of spotting increased. Among the Indian varieties those from Uttar Pradesh and Kashmir showed greater amount of

spotting than varieties of similar duration from other States in India. Amongst the foreign varieties, both early and late there was generally higher incidence than in varieties of Indian origin.

(2) *Seed treatment and germination*.—The germination percentage of 'spotted' seeds is generally lower than that of healthy ones. A seed treatment experiment was conducted to see whether fungicides could improve the germination of spotted seeds. Seeds of five varieties, T.1145, T.1242, T.90 GEB 24, and 'Benibhog' were separated into healthy and spotted. They were treated with the fungicides, Agrosan G.N., Arasan and Phygon at the rate of 1/400 by weight of seeds and germinated in pots. An untreated control series was also sown side by side. One lot of seeds was treated and sown in February 1949 and another in July 1949. The spotted seeds gave a lower germination than the healthy. The fungicides had no general effect in improving the germination of 'spotted' or 'healthy' seeds in the two tests, but in February sowings there was significant increase in germination associated with Agrosan G.N. in the spotted seeds of the varieties, T.1242 and T.90 and in healthy seeds of T.1242 and GEB.24. The rate of germination was in general slow and protracted in February compared to July.

(3) *Effect of seed treatment on germination and yield*.—(Field experiments).—Field experiments were carried out with 2 early varieties, N.136 and B.76, one variety of medium duration, T.1145 and a late variety, T.1242. Agrosan G.N., Arasan and Cuprocid were the fungicides used. In the experiment during 1949-50, healthy seeds were separated out from spotted seeds in the 4 varieties. In 1950-51 healthy seeds were further fractioned into heavy and light by floating out the latter with 18 per cent. NaCl solution. These different types of seeds were treated with the 3 fungicides and sown in replicated field trials. Observations were taken on germination, disease incidence and yield. Healthy 'heavy' seeds germinated better than healthy 'light' and spotted ones. While there was no difference between the latter two in early varieties, spotted seeds were better than healthy light in the late varieties. The germination of the spotted and healthy 'heavy' seeds was improved by Agrosan G.N. in T.1145 and that of only healthy seeds in T.1242. No effect of fungicides on germination was noticed in the early varieties. Observation on disease incidence was confined to early varieties. In these there was no difference in tillering, in susceptibility to leaf and grain infection between the individual plants raised respectively from spotted and healthy seeds. There was no effect of the fungicides on yield in any variety.

(4) *Pathogenicity of grain spotting organisms*.—The most common amongst the fungi isolated from grains showing spotting were, *Helminthosporium oryzae*, *Trichoconis padwickii*, *Curvularia lunata* and *Cephalosporium* sp. In order to test the pathogenicity of the last three fungi on rice, the variety 'Benibhog' was grown in pots with sterilized and unsterilized soil and in each type of soil untreated seeds and seeds treated with hot water were sown. As the seeds germinated the soil was inoculated with cultures of the fungi and seedlings were observed for 20 days for development of infection. No seedling blight or death was noticed during the period. In another experiment 40 days old seedlings of 5 varieties of rice raised in pots were inoculated with spore suspension of the last three fungi. None of the fungi was able to produce leaf-spots. These three fungi are

therefore to be classed as weak pathogens which perhaps lodge inside the open flowers and cause spotting.

In order to determine how these fungi get an entry into the grain, isolations were made of individual grains in the ear at different stages of their formation and it was found that the fungi could be isolated only after the panicle had come out of the boot leaf and spikelets had started opening. From this it was inferred that the conidia of these fungi gain entry into the flower after their emergence, mostly during opening of the flowers.

IV. SEED TREATMENT AND VIABILITY.

Seeds lose their viability during storage in the monsoon period, but certain fungicides arrest this loss in viability. To understand how the fungicidal treatment confers the benefit in storage, an experiment was conducted in which treated and untreated seeds of 5 varieties of paddy (T.1145, T.1242, T.90, T.812 and T.412) were stored in large desiccators in the beginning of February 1949 over appropriate sulphuric acid dilutions in water to give 10, 25, 50, 75, 90 and 100 per cent. relative humidity levels. Samples of seeds were drawn periodically and tested for their viability, their moisture content and the internally borne microflora till November, 1949.

In the first 3 levels of R.H., i.e., 10, 25 and 50 per cent. there was no fall in viability, the moisture content decreased in the first 2 levels only but not in 50 per cent. R.H. and the internally borne microflora underwent no change throughout the period of test. Under 75, 90 and 100 per cent. R.H. of storage the moisture content of seeds went up from the initial level of 11-13 per cent. till it became 20 per cent. under 100 per cent. R.H.

There was a corresponding falling off in viability with the increase in moisture content. Side by side with the loss in viability the original microflora of the seeds gave place to bacteria and moulds, mostly *Penicillium* sp. Thus it is possible that the loss in viability which occurs in storage is due to the penetration of seed under those conditions by common moulds, which destroy the viability of the germ due to their activities. The treated seeds retain their viability under the same conditions as the fungicidal coating confers a certain degree of protection against penetration by externally occurring moulds. At the same time it was observed that in the higher relative humidities of storage, the fungicidal treatment had merely the effect of retarding the rate of loss of viability when compared with untreated seeds.

MISCELLANEOUS

Maximum yield potential.—The extent to which rice yields could be stepped up by adopting all the improved methods recommended departmentally is being determined every year in a block of 4-8 acres in the farm. In 1949-50 the land was grown with a green manure crop of Pillipesara (*Phaseolus sublobatus*) and 3-4 thousand lb. of green matter per acre was ploughed in, a week before planting. Besides this green manure, bone-meal was also applied at 100 lb. per acre just before the final levelling. The variety T.90 was transplanted in the second week of August. The crop was not fertilized with ammonium sulphate, lest it should result in rank vegetative

growth and lodge. The crop was harvested in the middle of December, and gave an yield of 2,600 lb. of grain and 4,600 lb. of straw per acre. The value of the crop, grain and straw less the cost of cultivation (about Rs. 140 per acre) gave a net return of Rs. 213 per acre, the cost of producing one maund of paddy being Rs. 4-4-3.

The experiment was repeated in 1950-51 with the variety T.1242. Instead of bone-meal, super-phosphate was applied this year and in addition 50 lb. of ammonium sulphate was also added two months after planting. The crop gave an yield of 2,537 lb. of grain and 3,900 lb. of straw per acre. After taking all the expenses into consideration, the net profit obtainable from an acre is Rs. 170 and the cost of producing one maund of paddy was also Rs. 4-4-0 during this year.

Optimum time of planting the common improved varieties.—This experiment has been conducted for the two years under report more or less on the same lines. Two of the most popular varieties T.1145 and T.90 were planted in five different dates beginning from 20th June for T.1145 and from 25th July for T.90 at intervals of ten days. Two ages of seedlings 30 and 40 days in the case of T.1145 and 35 and 45 days in T.90, were planted on each of the dates. The plantings were done in 2 sets, one in fields receiving 3,000-4,000 lb. of green manure and another wherein, in addition to green manure, 20 lb. of nitrogen was applied as ammonium sulphate.

Postponing planting upto third week of August did not affect the grain yield in T.1145 and it is only in last planting, i.e., on 29th August, the yield showed a drop. However, the yield of straw went down rapidly in plantings done later than first week of August to the extent of 30 to 70 per cent. as compared to July plantings. With respect to the time of planting, 40 days old seedlings were found better than 30 days old. In the case of T.90, the results of the experiment for two years were not consistent. In 1949-50, the early plantings gave the highest yield and the yield rapidly dropped in plantings done beyond the middle of August, such drop amounting to 25% of the yield. But in 1950-51, it was noted that the late plantings were as good as July plantings. The straw yield was, however, lower in late plantings in both the years. 35 days old seedlings did better than 45 days old seedlings in the variety. With regard to manuring, the application of ammonium sulphate had no effect over a basal dressing of 4,000 lb. of green leaf in both the varieties.

Green manuring.—An experiment was carried out to assess the relative merits of normal green manuring, i.e., growing green manure crop *in situ* and incorporating it before planting and sowing green manure with paddy and incorporating the same at the time of *beushening*. The yields from the normal green manured plots and from the plots where the green manure was sown with rice were 2,015 and 1,775 lb. respectively, while under no manure 1,590 lb. was obtained. Thus, an increase of 26.7 and 15 per cent. respectively was obtained over the no-manured plot. The normal green manuring was better than the second method.

Double cropping in canal irrigated lands.—The following systems of cropping are being tried in an experiment for the last 2 years to find out which of them would give the best return to the cultivator.

- (1) Jute (Kharif) followed by green manure and followed by short summer rice in January-April.
- (2) Short rice (Kharif) fallow in October-January and short rice again in January-April.
- (3) As 2, but with a green manure crop during the intermediate fallow.
- (4) Long duration rice (T.1242) in Kharif, followed by a short duration rice in January-April.
- (5) As 4, but with a green manure crop before Kharif rice.
- (6) Medium duration rice (T.1145) in Kharif, followed by a short duration rice in January-April.
- (7) As 6, with a green manure crop before Kharif rice.

The results of the experiment showed that raising a jute crop, followed by a green manure, followed by short summer rice crop appeared to be the most profitable. For double cropping in canal irrigated areas, the best returns would be obtained from treatments 5 and 7; the yield of grain obtained from both the crops being 3,889 and 3,949 lb. respectively.

Intensive Cultivation Centre.—Propaganda and demonstrations in methods of cultivation were carried out in the Intensive Cultivation Centre during the 2 years. The average yield per acre in the Intensive Cultivation block was 27 mds. as compared to 15 mds. obtained in the same villages. The extra expenditure incurred by the cultivator due to green manure seed and fertilizers, was Rs. 20-5-0 per acre. The value of the extra yield of grain and straw obtained was Rs. 78-8-0 and the net profit realised was Rs. 53-3-0 per acre which should be considered highly satisfactory. The demonstration of growing a second crop was also a success in the Intensive Cultivation Centre. In good lands, where cultivators were earnest and planting was done in time, an acre yield of 20-24 mds. of grain was obtained. Where the lands did not have good drainage facilities, the yield was of the order of 15—18 mds. per acre. It was only in cases where the growers were indifferent and the plantings were done late in February that the yields were low, 8-10 mds. per acre.

Seed supply.—About 3,600 mds. of seed were made available for distribution during both the years.

District trials.—Trials were conducted in Cuttack district to demonstrate to cultivators the advantage of transplanting over broadcasting and also of applying sulphate of ammonia to paddy. The advantages of green manuring was also demonstrated in separate series of trials. Results from 23 different locations in the district revealed that transplanting gave small increases in yield over broadcasting, while application of ammonium sulphate at 20 lb. N per acre resulted in 23% increase in yield over a control yield of 2,199 lb. Green manuring also gave 20% increase over a control yield of 2,150 lb. per acre.

Improved implements in rice cultivation.—There are a large number of simple implements used in rice cultivation and processing of grain in Japan. Through the courtesy of the Ministry of Agriculture and Forestry, Tokyo, the Institute has been presented with

some of these machines, which have been tested for their suitability to Indian conditions. Only the hand operated ones could be tested in absence of electric power in the Institute.

(a) *Puddling*.—For this operation a puddler manufactured by P.S.G. & Sons, Coimbatore, was found to be more efficient and economical than wooden or iron ploughs. The comparative cost of preparing the same condition of puddle per acre being Rs. 22, Rs. 18 and Rs. 15 respectively for country plough, iron plough and puddler.

(b) *Drilling and weeding*.—For this purpose *Dania* Seed Drill worked with bullock power was used. The drill was found to work satisfactorily provided the field was well prepared without clods and the drilled crop gave as good an yield as the broadcast crop, besides there was a small saving in the amount of seed. To get the maximum benefit from the crop sown in lines an efficient bullock worked weeder that can be used in wet or semi-dry soils is required.

(c) *Threshing of rice*.—A hand operated or pedal thresher from Japan was compared with the common methods of threshing, *viz.*, bullock threshing and threshing by beating the sheaves against a hard surface. The Japanese thresher was found to be very efficient and comparatively cheap. A *Dania* power thresher was also tested. While this can be thought of only where holdings are large, the Japanese pedal thresher can be very useful even in small holdings.

(d) *Processing of rice*.—A hand worked Japanese 'Iwata' type sheller was tested and compared with a sheller manufactured by P.S.G. of Coimbatore on the model of a Japanese machine 'Cicoco'. The 'Iwata' Japanese sheller was found to be more efficient than the P.S.G. manufactured one. The sheller, unlike hand pounding and hulling machine, only removes the husk and leaves the whole bran layer in tact. The required polishing can easily be done in the ordinary *Dhenki*. The outturn of *Dhenki* is 120—150 lb. per day of 8 work hours while about 600 lb. could be hulled by the Japanese sheller.

Tractor ploughing.—A Fergusson tractor run on petrol, lent by the Central Tractor Organisation was tried. This is small and light and has good manoeuvrability. Its advantage over heavier tractors consists in its hydraulic control which helps in reaching all portions of the fields without disturbing the bunds. It was used to plough in dry condition all types of soil in the Institute from sandy loams to heavy clays, although these clays cannot be compared to the heavy clays of Peninsular India. The tractor worked efficiently in all these types of soil in the dry condition for initial preparation of the land, ploughing 5"-6" deep. In wet soil or even slightly wet soils the wheels of the tractor sink and start slipping. Even for this tractor the size of the field should not be too small, not less than 30-40 cents. The tractor ploughed 3-3½ acres in a day of 8 hours at a cost of Rs. 10 per acre. With tractor run on powerine it may be reduced to about Rs. 7-8-0. This should be considered more economical than bullock ploughing where to get the same results the cost may go up to Rs. 15 per acre. Apart from cheapness the advantage

of tractor ploughing consists in the expeditious preparation of the land which is an important factor in large holdings.

VISITORS

The prominent visitors to the Institute during the period under report were Shri R. K. Patil, Food Commissioner, Dr. Ignatieff and Dr. Kirk of FAO, Dr. Edward Shim of ECAFE, Dr. Yin of UNESCO and Prof. Sampetro of Rome.

Dr. B. Viswanath, Regional Commissioner of Food Production, Hon'ble Shri Roche Victoria, Minister for Food, Madras, Hon'ble Shri Tirumal Rao, Deputy Minister for Food and Agriculture, Dr. R. R. Williams from U.S.A., and Prof. Muntzing from Sweden.

Training:

Two officers of the Agricultural Department, Sri S. C. Ratha of Thailand and Sri P. V. George of Travancore-Cochin State were given training in rice breeding and genetics for 7 months at the Institute in 1949-50.

One officer of the Mysore Agricultural Department, Shri Srinivasamoorthy was given training in rice breeding and genetics for 8 months from July 1950 to January 1951.

Publications:

1. Ramiah, K. and Padmanabhan, S. Y., 1949. Seed treatment of Rice (Abst) *Proc. Indian Sc. Congr.* 1949.
2. Padmanabhan, S. Y., 1949. Occurrence of Fungi inside rice kernels. *Curr. Sci.* 18 pp.: 442-443.
3. Joshi, L.M., Pantulu, V.R. and Padmanabhan, S.Y., 1950. Control of water hyacinth with hormone herbicides: *Indian Farming*, XI. pp. 545-546.
4. Ramiah, K. and Vachhani, M.V., 1950. Features of rice work in Japan and how they differ from those in India. *Indian Farming*, XI (2).
5. Ramiah, K. and Vachhani, M.V., 1951. Farming under irrigation. *Indian J. of Power and River Valley Development* I:2.
6. Ramiah, K. and Ghose, R.L.M., 1951. Origin and distribution of cultivated plants of South Asia—Rice. *Indian J.Pl. Breed and Genetics*, 11. pp. 7—13.

Rev.

